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The Application of FCS-based Architecture in the Flexible Manufacturing System

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Abstract

Due to the unique features of “flexible” and “ Automation ”, Flexible manufacturing system (FMS) has accessed wide range of applications in modern manufacturing. Through the field bus control technology to achieve the real-time communication, and elaborates the application of FCS architecture in FMS.

Keywords- FCS; flexible manufacturing system (FMS);Field bus; communication; network system

Flexible manufacturing technology is a fast developing modern processing method which is in the technical support of the modern mechanical manufacturing,automatic control and computer, in order to adapt the needsof a variety of automated production, and possesses manyprominent advantages compared with the traditional machining methods.

1. The communication development situation of FMS

At present, with the rapid development of FMS, no matter the CNC technology, equipment unit or control software is quite mature, but the parts of network informatization and control modes need further development. Now the control modes of FMS are mostly adopt the DCS mode of distributed control system, which have some problems such as poor extensibility, weak information integration capability, lack of system open and difficult to maintain. Moreover, with the increasing market competition, enterprise informatization requires more and more advanced upper layer network technology, but at the lower layer of the network industry need some improvement, that resulted in the information includes the lower layer and the upper layer is difficult to achieve the unified management of resource sharing and production
process.

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Throughout the FMS, the information transmission between management and unit layers is mainly by PLC and CNC programs, production scheduling, etc., it belongs to static information , less demanding on the real-time communication, and it can realize by the standard Ethernet; in unit and equipment layers, device information transmission belongs to dynamic information, higher requirement in real-time, immunity, fault-tolerant, so it must be applied network technologies in the industrial field and manufacturing areas.

Field bus is an industrial field network communication technology, its appearance and rapid development provided good solutions for some problems mentioned above throughout FMS development, field bus is not only an underlying communication, to replace the analog technology by digital technology, the key point is the FCS gradually replaced the traditional independent control system and DCS distributed control system, and realized the integration of intelligent instrumentation, telecommunications network and the control system.

2. The FCS of FMS

In order to overcome the shortage of traditional centralized control system and the DCS system, combined with the most popular fieldbus control technology and industrial Ethernet technology in current industrial automation, put forward to the FCS architecture of FMS, as shown in Figure 1. In this project, the system adopts the three-layers communication structure named device layer, process control and management.

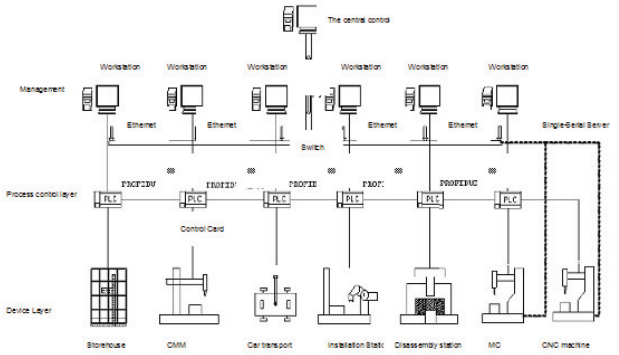

Figure 1 communication network system of FMS

In management layer, the main task is to prepare the production plan, assign tasks, the job scheduling as well as CNC code transmission, etc. Process control layer is consisted of master control computer and industrial configuration software, responsible for the unit'soperating plans, monitoring for system status, etc. The device layer is mainly responsible for real-time control and information transfer for equipment.

Network communication in upper-layer adopts the industrial Ethernet communication to achieve data transfer, manage, instruction convey, resources configuration, resource share and site monitoring, etc. The central control computer pluged into the PCI slot directly by CP5611 communication card of Siemens (model 6GK1 561-1AA00), and connected to the network by the industrial Ethernet switch (model SCALANCE X-108), which can provided a 100Mbps network speed. The central control computer can not only be easily connected with network via Ethernet and workstation computer for data exchange and State monitoring, etc., but also progressed the underlying data acquisition and expansion of the network by Siemens Ethernet communication module (e.g. CP243 CP343-1 or-1) and programmable controller. In this system, the management layer can transfer the production tasks, production scheduling, NC program

and PLC program and other information to the process control layer via Ethernet. This control method has some advantages such as simple, maintainability, and low-cost, etc.

The communication in the lower layer, it selectedPROFIBUS fieldbus communication to realize the sites communication and the token of delivery and transfer.

The system adopted single master system which has a bus interface, regarded the main controller Siemens PLC S7-314C-2 DP master station as the primary station, other PLC as the slave stations, sent the signals to the PROFIBUS bus from the main station, and transferred the data to PLC and control the decentralized I/O device.

Using the PROFIBUS system must carry out the configuration and parameterization to the system and the other sites, we used SIMATCI S7 programming software to configure in the network, the system needed to configure network under the STEP-7 environment and prepared system control PLC program. Figure 2 shows the configuration diagram in main station S7-300PLC, the system of a single master station, the sites was connected to PROFIBUS network made up a logical topology loop by address order, the main station can sent or read data to the slave sites after accessing the token.

After configuring to the main station hardware, you can take PROFIBUS network configuration, the various parameters of network will be completed when configuring, to achieve the data transmission in PROFIBUS network by calling system function block, then it's very convenient the main station PLC of programs control the slave sites in PROFIBUS networks.

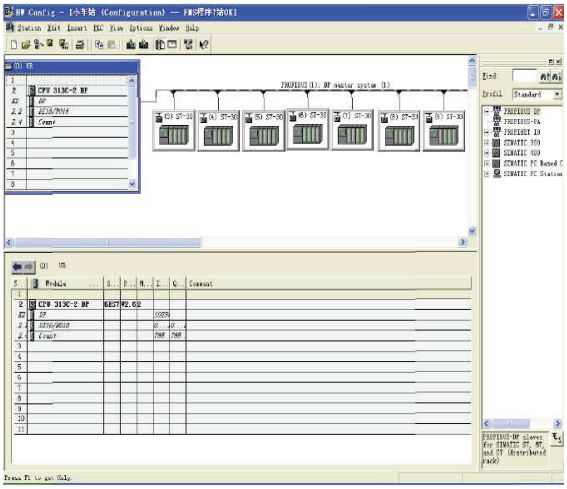

Figure 2 hardware configuration diagram of main station S7-300PLC

The Ethernet communication in the upper layer, we developed the CNC program transferred software by Winsock programming ,and integrated the CNC equipment and upper control computer based on the advanced technologies such as CNC, communication, computer and network, etc, to achieve the information exchange among the distributed CNC control in FMS, manufacturing facilities and upper layer computers. It can effective solved some general existed problems in CNC equipment, such as the NC program transfer can only through RS232 serial port; program transmission adopt in the form of stand-alone or a notebook, frequent hot plug easily burn-machine interface; confusion of the NC program management , generally respective cared by the programmers, easily lost or incorrect operation.

Depending on the system requirements, we made sure a star topology structure based on a single serial device server , the features of this program were each serial CNC devices was equipped with a single serial device MOXA DE211 servers, one side connected to the serial port through the RS232 interface

and the other side connected to the LAN through RJ45 interface and shielded twisted pair cable, to realize the direct connection between any equipment with the Ethernet, reached that any computer in Ethernet that can directly control any CNC equipment.

3. The transfer fromWinsock controls to NC programs

Winsock, that is a socket, it's a communication mechanism in the network interprocess, a Socket correspondent one side of the communications, network communication Socket interface model regarded communication host or the processes as a Socket, which can be named and addressed by the communication endpoints, a being used Socket has its type and processes associated with it. Each net work communications correspondent two Sockets including the local host Socket and remote host. The Socket interface defined a number of functions, which can be calling to develop TCP/IP network applications programmers by the programmers. We adopted the TCP/IP Protocol in the software, the Socket has three types: stream sockets (SOCK_STREAM), datagram sockets (SOCK_DGRAM) and raw Socket (SOCK_RAW), a streaming socket defined a reliable connection-oriented service for error-free, non-duplicate order data transfer. The datagram socket defined a connectionless service, data was transferred by independent messages, the packet is unordered, and hard to guarantee reliable, and error-free. The raw socket allows accessing the lower layer protocols such as IP or ICMP directly, mainly for the testing implemented by the new network protocol, etc. A streaming Socket using the TCP protocol which was connection – based, that is, only by establishing a connection first, you can communicate with each other, so that can guaranteed the data transmission was correct, and sequential. So this article used a streaming Socket for network program in switched Ethernet DNC communications system development.

Under the Visual Basic environment, using the Winsock control can achieve the purpose of CNC program transmission. A complete connection must contains transmission of both sides, with the aim of establishing a communication programs using TCP protocol, when establishing a connection by Winsock control, we need to consider two aspects: one is the Server program, the other is the Client program. Server-side is the side to respond to Client-side, so it must be possible to know ask for the request of connection and respond it, then the mutual exchange of data.

3.1 The procedures in Server-side should be established as follows:

- The Port number is decided to use.
- Began to listen the connection request by the network card and the Port.
- After a successful connection, the server sends initialization information to the serial port .Initialization information includes the serial device server communication parameters with the CNC machine tools (baud rate, data bits, stop bits, parity, flow control protocol).
- Once receiving the serial connection request, accept the connection request .
- After the initialization succeeds, send the file data from the server to the serial port.

3.2 The procedures in Client-side should be established as follows:

- IP and Port number decide to call (settings of remote server).
- To establish a connection with server side by the Connect method.
- When the connection is completed, to transfer data to the server side by Send Data method.
- In the event of Connect Request , focus on the action of data from requiring side as receiving method (use Get Data),save it in the variable and take subsequent processing. When one side carries out the action, it will cause Close events in the other side.

The design of user interface shown as in Figure 3, mainly including the parameter settings, send and save for NC code files.

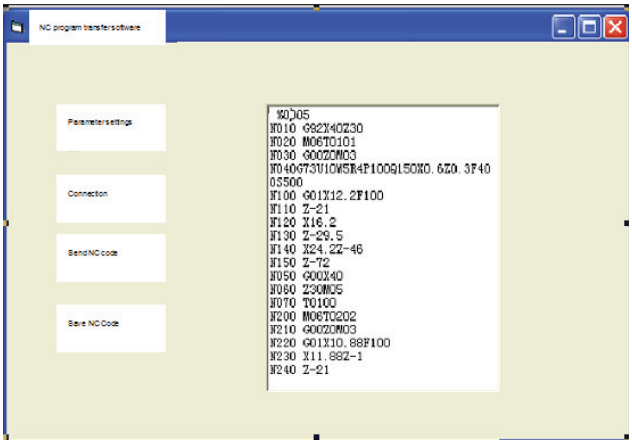

Figure 3 user interface of NC program transfer

Server-side core programs are as follows:

To create the socket Server.

Add Winsock controls, named dnc, set 0 for the index property, and increase the following codes in the LOAD

event:

```
Sub form load
Dnc(0).localport=2000（） /* avoiding the conflict
between the server port and the well-known port */
Dnc(0).listen /* Start Listening */
End Sub
Accept the connection request from client
Once the client connects to the server, which will
executive order of Connection Request.
Dim socknum as integer
Socknum=0
Sub DNC-ConnectionRequest (index as integer,ByVal
requestID As Long)
Socknum=Socknum+1
Load sockSever(socknum),
Dnc(.socknum).accept requested /*accept a
connection requirement by the method of Accept*/
End Sub
Accept the data from Client
Once receive the data from Client, the server will
executive order of Data
Arrival
Sub DNC(index)-Data Arrival (ByVal bytes Total As
Long, Index as integer)
Dim s As String
```

```
Dnc(index).GetData s /*To receive data by the method
of GetData */
End Sub
Send data to Client
Click “Send”
Sub Send-clkick（）
dnc.(n).SendData text2.text
End Sub
Respond client to close junction
Once the client closes the connection, the server will
executive order.
Sub dnc-close(index as integer)
Dnc(index).close /* close the current connection */
Dnc(index).listen /*Restart listening*/
End Sub
Close junction initiatively
Sub Form1-Unload(Cancel as integer)
Dnc(n).close
End Sub
```

FMS adopts a double-layer network structure: an upper layer for Ethernet, the lower-layer for Fieldbus. The fieldbus technology ensures that the system's advanced nature and popularity as the most popular and advanced automation technology. Moreover it’s easy to upgrade and provides enough space for the further enhancement. Not only can the system takes teaching and scientific research of FMS system principle, but also shows some technologies such as field bus, the PLC, motion control, CAD/CAM, network y, configuration software, etc.

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